Notes for Responses to Questions/Concerns Raised by OFIC
Re: Protecting Cold Water Criterion of the Temperature Standard

Oregon Department of Environmental Quality

Date: 5/14/2014

Questions/Assertions from Forest Industry Representatives:

1. Paired watershed studies alleged to show no correlation between temperature and salmon, steelhead, and bull trout (SSBT) population metrics.
    a. What was the temperature response in these studies?
        i. Hinkle Type-N stream-adjacent harvest (Kibler *et al* 2013):
            1. Flow increases on streams post-harvest (76-161%).
            2. Shaded due to logging slash.
            3. One stream (Fenton) had insignificant shade change (-4%), change in maximum temperature was -1.6°C.
            4. Three streams had shade decreases (-22 to -29%), change in maximum temperatures were +0.6, +0.7, +1.1°C.
            5. Pooled results for all Type-N streams indicate no significant change in maximum, mean, or minimum temperatures: No overall change.
            6. No significant temperature changes at watershed outlet (South Fork Hinkle Creek).
        ii. Hinkle Type-F stream-adjacent harvest (Arne Skaugset, *personal communication*, compiled by Terry Frueh(ODF)):
            1. Average changes of +0.4°C for stream temperature, -9.5% canopy cover on average.
            2. Temperature probes align with tributaries, not necessarily harvest units.
        iii. Alsea stream-adjacent harvest (Jeff Light, *personal communication*, compiled by Terry Frueh(ODF) & Paired Watershed Research Symposium (April 2013):
            1. Small Type-N stream: Stream temperature change was +0.5°C.
            2. Small Type-F (bottom of harvest unit): Stream temperature change was +0.7°C, -14% for shade.
            3. Small Type-F (bottom of unharvested reach downstream of harvest unit): Stream temperature change was +0.3°C.
        iv. Comparing Hinkle and Alsea Type-F stream-adjacent harvest with RipStream results (Compiled by Terry Frueh(ODF)):

Table 1. Summary data on changes in temperature, shade, and basal area for two WRC studies (Alsea and Hinkle) and RipStream.

Study (n=# of sites)	ΔT (ºF) (n=# of sites)	ΔShade (%)(n=# of sites)	Pre-harvest total basal area (ft.^{2}/ac.) within 100 feet of stream (n=# of sites)	Post-harvest basal area (ft.^{2}/ac.) within 100 feet of stream (n=# of sites)
Alsea (n=1)	+1.3 (+0.7°C)	-14	NA	37[2]
Hinkle	(n=3): +0.7[1] (+0.4°C)	(n=3): -9.5	Mainstem (n=4): 186	Mainstem (n=4): 149
			Type F tributary(n=2): 172	Type F tributary(n=2): 127
RipStream (n=18)	+1.3 (+0.7°C)	-7	Small Type F (n=4): 187	Small Type F (n=4): 87[2]
			Medium Type F (n=14): 207[2]	Medium Type F (n=14): 128

[1]Change in temperature was measured at junctions with tributaries, which does not necessarily correspond with the downstream end of a harvest unit.
[2]Total basal area excluding that of alders.

b. Did studies examine SSBT? What was general response? **[ODFW]**
   i. Hinkle did not look at SSBT, did look at resident cutthroat trout.
      1. Cutthroat: Small increases in size & total biomass (continuation of pre-harvest upward trend?).
   ii. Alsea did look at coho salmon & resident cutthroat.
      1. Coho: No response.
      2. Cutthroat: Adult biomass increased, juvenile size decreased, no response otherwise.

c. Are resident cutthroat a good proxy for SSBT? **[ODFW]**
   i. While sea-run cutthroat have similar temperature requirements as other salmonids, resident cutthroat do not have to undergo smoltification in order to survive ocean conditions. As a result, increased feeding in areas with higher temperature would not affect timing of smoltification as it does with anadromous fish (Trotter 1989).
   ii. Resident cutthroat trout have shorter lives & mature more quickly than sea-run cutthroat trout (Trotter 1989).
   iii. Irrespective of potentially different physiological needs, research indicates that cutthroat populations are found in lower abundance in secondary forest than in clear cuts or old growth (Murphy *et al* 1981).

d. What is the appropriate inference for the studies, with regard to fish? **[ODFW]**
   i. Reach level acute effects on fish population are the appropriate inference.

ii. Short-term (ecologically speaking), local examination of population dynamics, primarily for cutthroat trout.
    1. Shows no acute damage to local cutthroat populations.
    2. Limited inference for SSBT.
    3. Limited inference for long-term local population effects.
    4. Limited inference for watershed, sub-basin, and basin level effects.

iii. Therefore, cannot draw conclusions about SSBT at Evolutionarily Significant Unit (ESU) or sub-population level.

e. Is this assertion relevant to the purpose & construction of the temperature standard?
    i. The purpose of the standard is maintenance and restoration of natural thermal regimes. Diversity in habitat conditions enhances ecosystem resiliency.
    ii. The Protecting Cold Water (PCW) & Human Use Allowance (HUA) criteria restrict anthropogenic warming in waterbodies below & above the biologically-based numeric criteria (BBNC), respectively, & implement the purpose of the standard. The BBNC are primarily thresholds for identifying impaired waterbodies. The standard protects cold-water aquatic communities, including amphibians, macroinvertebrates, & native fish of all types.
    iii. The BBNC are set at the high end of the optimal temperature range for salmonids (US EPA 2001).
    iv. Meeting the standard preserves the capacity of waterbodies to assimilate natural fluctuations in temperature due to year-to-year climate variations & to better maintain cold-water communities in a warming climate.
    v. While the standard can be used to restrict activities that cause immediate, acute harm at the reach level, it is a regime standard designed to protect entire aquatic ecosystems from both acute & chronic anthropogenic impacts.
    vi. Therefore, the assertion ignores the larger purpose of the standard to focus on short-term, reach-level effects.

2. Alleged that there is no scientific support for the conclusion that small increases in water temperature (in reaches below the numeric criteria) are harmful to SSBT in either a localized or landscape sense, short- or long-term. **[ODFW]**
    a. We agree, to an extent, depending on how "small" is defined. That is one purpose of the 0.3°C limit on anthropogenic warming. We have a high degree of confidence that warming at or below this limit will not affect fish or cold-water communities (DEQ 2003: Temperature TAC Summary Report).
        i. Effects are on a continuum; the further we increase temperature from the natural thermal potential, the higher risk there will be for the fish.
        ii. The BBNC are set at the high end of the optimal temperature range for salmonids (US EPA 2001).
        iii. Consideration of accuracy of measurement is another reason for the 0.3°C limit. The State's policy on stream temperature is that natural thermal regimes should be protected and, where necessary, restored.

   iv. Under the Clean Water Act, existing high quality waters cannot be degraded unless it is necessary to accommodate important economical or social development in the area in which the waters are located, and BMPs are achieved for nonpoint sources.

b. Heating of headwaters reduces the extent of downstream waters at optimal growth & optimal physiological temperatures & increase the extent of downstream waters at high-risk & lethal temperatures for rearing & migration.

c. Fish are poikilotherms, so metabolic rates & processes are regulated by the temperature of their environment (US EPA 2001).
   i. Faster metabolism results in faster growth up to the optimum growth temperature provided adequate food is available.
   ii. Faster metabolism results in energy stress when adequate food is *not* available.
   iii. Ability to avoid predators adapted to warmer water decreases with increasing temperature. Swimming is less efficient at higher temperatures (US EPA 2001).
   iv. Invasive species often do better in warmer temperatures.
   v. Changes in disease resistance with increasing temperature (US EPA 2001):
      1. Constant temperatures below 12-13°C often reduce or eliminate both infection and mortality;
      2. Temperatures above 15-16°C are often associated with high rates of infection and notable mortality;
      3. Temperatures above 18-20°C are often associated with serious rates of infection & catastrophic outbreaks of many fish diseases.
   vi. If adult fish are exposed to temperatures above 13-15.6°C during the final part of upstream migration or during holding there is a detrimental effect on the size, number, and/or fertility of eggs (US EPA 2001).
   vii. Changes in behaviors can result from increases in temperature below the numeric criteria (US EPA 2001).
      1. Warmer temperatures may lead to earlier out migration in salmon & reduced ocean survival (Holtby 1988).
      2. Smoltification is very temperature sensitive, even to temperatures lower than the BBNC.

d. Multiple stressors in the environment must be considered. By preventing or reducing temperature stress, we reduce the risks due to multiple stressors on fish populations (see Baird & Burton 2001, US EPA 2001).

e. Water quality (particularly summer stream temperature) was identified in the Oregon Coastal Coho Assessment & Oregon Coastal Coho Conservation Plan as the secondary bottleneck for most coastal coho ESUs.

f. When there is uncertainty, DEQ must make conservative choices to ensure protection of the resource.
   i. Uncertainty due to dynamics of the system (stochasticity).
   ii. Uncertainty due to our incomplete understanding of the system.
   iii. Uncertainty due to using sample data to observe the system.

3. Alleged that increases in temperature (at levels seen in RipStream) will diminish to less than 0.3°C within 300m on average. What can we say about downstream effects (in detail)?
    a. Physics of heat gain/loss.
        i. During summer, efficiency of heat loss is much lower than that of heat gain via solar radiation.
            1. In open canopy streams, input of solar radiation typically composes about 50% – 90% of the total heat energy flux (Johnson 2004, Benyahya *et al* 2012) & is the primary driver of heat transfer related to stream temperature change (Figures 1 & 2).
        ii. Added flow (increased mass of water) dilutes heat, but most heat remains in the system (e.g. Hannah *et al* 2008).
            1. Harder to detect the effects of a *single* source as water moves farther downstream.
            2. Temperature is a measure of average thermal energy content, but DEQ also tracks thermal energy loads & fluxes (kcal) in TMDLs & other water quality programs.
        iii. On small streams, DEQ HeatSource modeling indicates long distances (1000 meters +) are required to lose heat energy via evaporation and longwave radiation.
            1. The loss is slow because these fluxes are the primary processes for loss of heat, and they represent a small proportion of the total input from increased solar radiation (Figure 1).
            2. Tributary & groundwater mixing are held constant; only effects of vegetation change are modeled.
        iv. HeatSource modeling on 2 RipStream sites (5556 & 7854):
            1. Agrees well with field measured responses at the end of the harvest units;
            2. Shows persistent temperature increases a kilometer or more from the end of harvest units (Figures 3 & 4);
            3. Harvest of additional downstream unit on 5556 creates greater increase at confluence with Drift Creek (Figure 5).
    b. Trask Study results?
        i. Preliminary results shown in Trask presumably showed privately harvested Type-N streams did not have readily detectable effects at downstream probe.
        ii. Small headwaters (small Type-N) streams often behave differently & have small flows compared to fish-bearing reaches.
            1. There is a great deal of change in heat capacity between harvest reaches & downstream sites, due to greater flows.
        iii. The format of data presented to the GNRO is difficult to understand—need more information to have an interpretation of this data.

            1. For example, does not appear to be harvest-related temperature changes on Type-N streams in harvest units. If true, wouldn't expect changes at downstream sites.
      iv. Between Type-N harvest units & downstream probe is a RipStream study site.
            1. During pre-harvest (2006-2011) period of Trask Study, RipStream site was in post-harvest condition (harvested in 2005, post-harvest year 1 was 2006).
            2. RipStream site had challenging-to-interpret temperature behavior. 2W (control) probe had post-harvest increases & there was not much harvest in the Riparian Management Area, so unable to see any effects at 3W (treatment) probe.
            3. Does this site confound interpretation of downstream effects from headwaters harvests?
   c. Davis *et al* (in review) analyzes temperature behavior downstream of RipStream harvest units (single harvest).
      i. Average increase on private lands *as harvested* was 0.7°C. Average case for Davis *et al* travel distance for 0.7°C →0.3°C ≈300m. Minimum case is ≈120m, maximum case ≈1125m.
            1. Only 6 of 18 private sites were harvested to or near FPA minimum retention targets.
      ii. Average increase on private land *as modeled to FPA minima* is 1.7°C (draft result). Average case for Davis *et al* travel distance for 1.7°C →0.3°C ≈650m. Minimum case is ≈140m, maximum case ≈2700m.
   d. Cole & Newton (2013) showed that with uncut units interspersed with harvest units, stream reaches showed overall increases in temperature trends 2 or 5 years post-harvest for 3 of 4 study reaches.
   e. If taking a non-conservative approach to the effects of a single harvest, then we must address actual landscape conditions & the effects of multiple harvests.
4. Alleged that 2% of landscape in "early years" of rotation. What is the typical range, and what can we say about that?
   a. Two questions:
      i. How are the "early years" of the rotation being defined? It appears this figure may be % harvested per year on an even-flow 50-year rotation.
            1. An appropriate thermal recovery window is 7-15 years, given the literature on temperature/shade recovery (Johnson & Jones 2000; D'Souza *et al* 2011; Rex *et al* 2012; RipStream data, *unpublished*).
            2. Ten years is a reasonable mid-range timespan (See studies above; also Sherri Johnson, *personal communication*).
      ii. What spatial scale is being considered? How does ownership vary across space?
   b. Answers:
      i. 2% harvested per year on average for a 50 year rotation. Rotation length is more often 40 years, so 2.5% of the land harvested per year on average. For a

10 year temperature recovery timespan, 25% of industrial forestlands would be in thermal recovery.

ii. There is high variation in percent ownership of forestlands (federal, state, municipal, private nonindustrial, private industrial) by sub-basin and basin and in harvest patterns.

iii. The average percentage of private forestland (65.1% of total land area) in the MidCoast basin in the 10-yr thermal recovery period is 17% for the time period 1985-2009. The total for all land uses combined is 10%.

1. An additional 5% did not have tree cover before 1985 & has not grown trees subsequently.
2. Varies over time & space.
    a. In 2008, 39.9% of private forestland in the Middle Siletz River watershed was in thermal recovery.
    b. In 1996, 5.3% of private forestland in the Drift Creek watershed was in thermal recovery. [34.9% in 2008]
3. Disturbance is calculated in rolling 10-yr intervals based on change in Landsat land cover from 1985-2009 (Figure 6).
4. Disturbance includes both harvest & fire.
5. Consistent with digitized harvest units area in ODF Vantage database (Kyle Abraham, *personal communication*)

iv. In ODF's landslide study, (Robison *et al* 1999) 17% of study areas were in age class 0-9.

c. Prior to Euro-American settlement, fires created a heterogeneous (patchy) landscape with variable fire severity &varying intervals between fires.

i. Fire return intervals in western Oregon range from 100-400 years. Shorter intervals typically are associated with less severity (Morrison & Swanson 1990).

ii. Agee (1990) estimates that historically an average 0.24% and 0.67% of cedar/spruce/hemlock and Douglas-fir forests, respectively, burned annually.

iii. Cedar/spruce/hemlock average per 10 years=2.4%; Douglas-fir average per 10 years=6.7%.

d. Wimberly (2002) estimates that a median of 17% of Oregon's coastal province would be in early successional condition (<30 years since fire).

i. These fires are not all stand replacement but vary in severity.

ii. Using 10 years as above, Wimberly's estimate gives 5.67% of forestlands historically in thermal recovery.

iii. Swanson *et al* (2011) document the differences between natural early succession and clearcut harvest.

e. High-severity fires leave more wood & live vegetation than clearcut harvest. Fire return for high severity fires is typically 200 years (Wimberly 2002), compared to harvest rotation of 40 years.

f. Temperature 303(d) listings & TMDLs exist across Oregon's landscape.

g. If only 2-6% of landscape were in recently harvested (≤10yrs since harvest) condition at the 6th field scale, then there are significantly reduced risks of water quality impacts & fisheries impacts.

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